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EXPERIMENTS ON DISCRIMINATION OF CLANGS FOR DIFFERENT INTERVALS OF TIME.

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PART I.

The following research was suggested by the results of experiments on memory carried on by a beginner's class in psychology in Stanford University.

These experiments were of the usual kind on syllables, numbers, weights, tones and lines. They were carried out under fairly favorable conditions as regards isolation, and with much earnestness by most of the class—a condition not always present in beginners' classes in experimental psychology.

The general results of the experiments were not such as to substantiate all the laws of memory as commonly laid down in the text books. It was not found, for example, that the flight of time up to 60 seconds—the longest interval used—made any marked difference in accuracy of discrimination of lines for most of the students. The majority seemed to discriminate as well with a 60-second interval as with 10 or 3 seconds. It was further noticed that the degree of strain of attention during the interval between two stimuli seemed to make but little difference in accuracy of discrimination. One student, *e. g.*, who filled in longer intervals with interesting reading, discriminated between pairs of lines, quite as well for the longer intervals as for the shorter with direct attention.

Again, while some were more accurate with the shorter intervals, others were more accurate with the longer, so that the average of the judgments of about 30 students was almost alike for all time-intervals used. But the experiments on each individual were too few in number, and performed under too rough conditions, to serve other than as hints for more careful and extended work. They led the writers to think, however, that the so-called laws of memory for short intervals of time as commonly laid down in text books may be inaccurate; and, also, that the lumping together of experiments on series of syllables and numbers on one side, with experiments on the discrimination of pairs of successive stimuli on the other, under the common name of "memory experiments," is misleading.

Furthermore, the writers thought it might be worth while to repeat some of the experiments on discrimination of simple stimuli with different time intervals under the conditions of strained and distracted attention,—to repeat, for example, Wolfe's work on Tone Memory, and to supplement it with distraction experiments, in order to gain some insight, if possible, into the nature of the "memory image" of simple stimuli.

The literature of the experimental treatment of memory, so far as it is accessible to the writers, would not seem to indicate that the question of the effects of the flight of time on memory had been definitely settled, or, indeed, that it had been definitely determined what was meant by memory in experimental investigations.

The diversity of result obtained in the beginners' class, referred to above, seems to be a reflection of the diversity of result found in the several special investigations. Wolfe's¹ well known work on Comparison of Clangs, from which he obtains a logarithmic law similar to Ebbinghaus's law for the forgetting of nonsense syllables, will be discussed further on, along with the results of the writers' experiments. In regard to the classical research of Ebbinghaus, as well as of the supplementary work of Müller and Schumann, the writers, as indicated above, do not feel that the effect of the flight of time on a series of muscular actions, practiced till they can be executed mechanically, is to be placed in the same category with the discrimination of pairs of successive, simple stimuli, with different time intervals. As M. Bergson² says in the *Revue philosophique*, "The recollection of anything learned by heart, has all the marks of a habit. Like a habit, it is acquired by repetition of the same effort. Like a habit, it requires analysis of an action and then recomposition into the complete effect. Like any habitual exercise of the body, it is incorporated in a closed series of automatic motions which follow one another in the same order and take up the same time."

What is there in running through a complicated series of muscular actions which corresponds to the discrimination of two tones, except the element of the flight of time? The impressions of "like" or "unlike" expressed in judgments, are the data from which the accuracy of the so-called sensory memory is estimated; but the accuracy of reproduction of a series of muscular actions, more or less accompanied by sensory images, and discharging into one another more or less mechani-

¹ Wolfe : Untersuchungen ü. d. Tongedächtniss. *Phil. Stud.*, Vol. III, p. 534.

² Bergson : Mémoire et reconnaissance. *Rev. phil.*, Vol. XLI, p. 226.

cally, is the basis for measuring the memory for motor ideas, and a subsequent judgment of the degree of accuracy of reproduction does not form an essential part of the data. Moreover, the consciousness of the serial impressions retreats more and more with practice, into the marginal regions of consciousness, whereas, in the case of discriminative judgments, the attention usually becomes more and more concentrated and the discriminative powers increase with practice.

In this respect, Ebbinghaus's observation on the effects of recognition of syllables on retention seems very pertinent. He found, for example (*Das Gedächtniss*, S. 80), that syllables, which he had imprinted 8 to 16 times on a given day, appeared new and strange to him on rehearsing them the day following. When, however, the number of preparatory imprintings had run up to 57 or 64, the syllables no longer appeared strange to him on the succeeding day; he greeted them, if not immediately, at least in a short time, as old acquaintances. But he did not find that recognition of the syllables made any difference in regard to their retention. The number of imprintings necessary to memorize the syllables was as great with as without recognition.

Müller and Schumann¹ found a like result in the case of rows of syllables reconstructed wholly from rows already imprinted. When, however, the reconstructed rows were made up in *part* only from previously imprinted rows, they found a saving in time of memorizing accompanying recognition. But this latter condition was attributed by them to a great familiarity with certain syllables, or to some betterment in "disposition," in virtue of which attention and recognition were both increased. The quickening effect on interest of a familiar acquaintance in a mixed translocated series of syllables, as compared with the broad and general recognition of Ebbinghaus's experience, would certainly account for the difference in results. It would seem to the writers as if the classification of the two forms of mental process under the common name of Memory, rests on a loose analogy—viz.: the analogy between the motor tendencies together with more or less of sensory accompaniment, left by imprinting a series of muscular actions, and a so-called memory image resulting from imprinting a sensory image, which is supposed to exist centrally till it is compared with a peripheral sensation. Whether, however, this memory image as such exists in most of our discriminative judgments for small differences of stimuli is doubtful. As will be shown later, explanations of sensory memory based on the existence of a memory image involve one in absurdities.

¹Exp. Unt. ü. d. Gedächtniss. *Z. f. Psy.*, Vol. VI, p. 319.

Bigham's¹ experiments on memory are of the serial kind, but the imprintings were not repeated till the reproduction became automatic. Using 10 kinds of serial presentations—5 audible and 5 visible—he found, in general, an increase in errors of reproduction with the time. Nevertheless, taking the different kinds of presentations together, using all the syllables and all the numbers (as we understand it), he found that numbers were remembered better after 10 than after 2 seconds, and that syllables were “remembered very much better after 30 seconds than after 2 or 10 seconds.” But the reproduction of a series of visible presentations is often attended by, if not due to, muscular action. The names of colors, figures, and numbers are almost unavoidably pronounced as they are exposed, and it is questionable if in this kind of experiment, any more than in those of Ebbinghaus, we have mental processes similar to those involved in discriminating between pairs of stimuli.

Münsterberg² compared linear distances with intervals of 1, 3 and 10 seconds, and found an increase in variable error with the time. Lewy,³ elaborating on Münsterberg's work, found an increase in variable error with the time for intervals up to 60 seconds. Lewy used the method of mean error, which necessitated an adjustment of the comparison distance till it seemed like the same. This occurred after the time interval had expired. Consequently, in case the adjustment took a second, the time interval would have been stretched all the way from 100 to 20 per cent. of itself for the intervals from one to five seconds. As the writers used clangs rather than lines in their investigations, Lewy's objections to the use of clangs may be briefly noticed. In the first place he says that even with pure tones, harmonics can crowd into memory and disturb it. In the course of long experimentation with tuning forks, one of the writers has not found this to be the case. Lewy next objects, that by means of gentle “Mitsingen” the reagents would be able to fix the norm. The obvious answer to this is that the differences used in discriminative experiments are too small to be reproduced by singing. As Stumpf⁴ says: “Would the most practiced singer venture to produce 90 different tones within the half-tone interval from h^1 to c^2 ? But this is the number of differences that can be detected by practiced ears.” Lewy also found an increase of variable error with the time, in localizing points on the skin.

Some experiments by Paneth and Wahle, communicated by Exner, illustrate the contradictory condition of the memory

¹J. Bigham: *Memory*. *Psy. Rev.*, Vol. I, p. 453.

²Münsterberg: *Beit. z. exp. Psy.*, Vol. II, p. 163.

³Lewy: *Unt'g ü. d. Gedächtniss*, *Z. f. Psy.*, Vol. VIII, p. 231.

⁴Tonpsychologie, Vol. I, p. 163.

problems. Paneth¹ tried to reproduce a time interval by pressures on a key connected with a kymograph. As a result of 1,451 trials, he found that the "sharpness of the memory image" declined so little in the course of five minutes that the difference could not be measured by the method used. Wahle experimented with white disks on a black ground (surface magnitudes), and later with just observable differences of brightness. Exner does not give the details of these experiments—he simply says: "They were conducted with the same care and gave rise to the same negative results as Paneth."

The experiments of Baldwin and Shaw² and of Warren and Shaw³ are not strictly to be compared with those of Wahle, as they obtained their data from 'class experiments,' carried out for much longer intervals (10, 20, 40 minutes), which were 'filled' with class work. In general, they found a decrease in accuracy of selection or identification with increase of time. In reproducing a given square, however, the class error for 40 minutes about equalled that for 20. In regard to this the authors say that the class may have been tired or the paper on which the squares were drawn, too small. In view of the contradictory results of various experimenters, it is perhaps also admissible to say that, under the conditions, a class could reproduce a given square as well after 40 minutes as after 20.

Other experiments of Münsterberg⁴ as well as those of Smith⁵ are not considered here, partly because they are serial, and partly because they have to do with questions of distraction, which will be discussed in the second part of this paper. We turn, therefore, to a closer examination of Wolfe's experiments.

The stimuli used by Wolfe were clangs from an Appunn 'Ton-Messer,' and they lasted one second, as nearly as the operator could pull the stop. For the experiments of the first of the two periods into which the entire work was divided, 5 different clangs were used to avoid the possible formation of a sense of absolute pitch. The time intervals between norm and comparison ran from 1 to 120 seconds—the greater part lying between 1 and 60 seconds. Intervals up to 30 seconds were marked by a metronome. In this connection it is curious to observe that metronome beats have been used sometimes as

¹ Paneth: Versuche ü. d. zeit. Verlauf d. Gedächtnisses. *Cen. Blatt. f. Phys.*, Vol. IV, p. 81. Mitgetheilt von Sig. Exner. Cited also by Lewy, S. 234.

² Baldwin and Shaw: Memory for Square Size. *Psy. Rev.*, Vol. II, p. 236.

³ Warren and Shaw: Memory for Square Size. *Psy. Rev.*, Vol. II, p. 239.

⁴ Münsterberg: *Z. f. Psy.*, Vol. I, p. 115.

⁵ Smith: Attention and Memory. *Mind*. N. S., Vol. IV, p. 47.

a means of distraction, sometimes without being noticed, and sometimes with even the effect of fixing the attention on the regular stimuli.¹ It illustrates the complexity of the distraction problem that the same kind of stimulus should come to produce either fixation or distraction according to the attitude of the reagent. From the experiments of the first period with difference of 4 vibrations, as Wolfe himself says, not much is to be concluded, as the flight of time had but little effect in comparison with the uncertainty of the reagents in judging 'higher' and 'lower.' Perhaps the most pronounced result was that with no difference in vibrations between norm and stimulus ($\Delta=0$), the proportion of correct judgments was large with small time intervals, and fell off with increase in time. With $\Delta=8$, there was some, though not marked, increase of right judgments (r) over $\Delta=4$. In this case also r decreased with the time, though not so much as for $\Delta=0$. Similar results are found for $\Delta=12$.

In Wolfe's numerous experiments of the 'second period' 11 norms were used to avoid the formation of a sense of absolute pitch. These norms ran from 144 to 1,004 vibrations, giving opportunity, incidentally, to investigate the relation of liminal differences to pitch.

The number of reagents was 4—Wolfe himself acting at once as reagent and experimenter, giving far more judgments than any other reagent. For all reagents, and for all values of Δ , viz., 0, 4 and 8, there was a falling off in accuracy of judgment with the increase in time interval—the decrease being most marked for $\Delta=0$. Accordingly, the well known curves for tone-memory, together with the logarithmic law, are deduced from cases where there was no difference between norm and comparison.

The experiments of the writers were also performed on an Appunn 'Ton-Messer,' with the range of an octave, viz., from 512 to 1,024 vibrations with a difference of 4 between consecutive stops. The reagents were 4 in number—Mr. G. E. Libby, Mr. Wilson, Miss Steffens, and one of the writers (F. Angell). All could or would sing a little, but in Germany, at any rate, would hardly be regarded as musical. They sat with their backs to the instrument and ten (10) feet away from it. The matter of distance is not unimportant, as for a distance of less than a meter from the instrument reagents would be able to recognize a difference in the positions of two stops, differing by eight vibrations. Two of the reagents were unacquainted with the object of the experiments, and to this day three are unacquainted with the result. None of the reagents, during

¹ Wolfe : *op. cit.*, S. 530.

the course of the investigation, had the slightest information in regard to the results or the general trend of the experiments, nor were they aware of the differences judged. They were told to judge each pair of stimuli as if it was the only pair, and to beware of forming any theories in regard to the succession of norm and comparison. Of course they were to note anything in their judging which appeared to them noteworthy. On account of the variations introduced into the work by the experimentation on distraction, it was impossible to make use of a large number of norms. Accordingly, one of the three clangs corresponding to 540, 560, or 580 vibrations was used as *the* norm for a series of 10 judgments, and at the same time this norm might be varied 4 vibrations either way. Thus, in a series of 10 judgments the noun 560 might be raised to 564 or lowered to 556. In this way all danger of forming a sense of absolute pitch was avoided.

The reagents were told at first to judge merely "like or unlike," but before the practice period was over, they gave the judgments 'higher' or 'lower' without thought of "like or unlike." Accordingly the ratios of right and wrong cases in tables of for 'unlike' judgments are based on judgments of 'higher' and 'lower.' Doubtful judgments are divided proportionately between right and wrong judgments. The differences used were $\Delta=0$, $\Delta=4$, and $\Delta=8$, but as the reagents knew nothing in regard to the size or variations of Δ , their attention was presumably equally strained for all of its values. Nine time intervals were investigated, viz., 1, 3, 5, 7, 10, 20, 30, 40, 60 seconds. Along with the experiments ran a series with distracted attention, the results of which are incorporated with the pure memory experiments for the sake of economy of space.

For each time interval about 90 judgments were given by each reagent with distraction, and 90 without. Of these judgments about $\frac{1}{4}$ were given on a difference $\Delta=\pm 0$, the remainder being almost equally distributed between $\Delta=\pm 4$, and $\Delta=\pm 8$. Table I gives the actual results of experimentation after practice, and Table II gives the percentage of right cases in Table I for each value of Δ . As will be seen from Table II, the falling off in accuracy where $\Delta=\pm 4$ or ± 8 is small. It is more marked in the case of A than of the others, though one finds that A with $\Delta=4$ is as accurate for 60 seconds as for 5, and more accurate than for 40 seconds. S. on the other hand shows greater accuracy in judging these differences for the longer time intervals. For $\Delta=8$ her average per cent. for the 4 shortest intervals (1 to 7 seconds) is 56: for the 4 longest intervals (20 to 60 seconds) it is 59. For $\Delta=4$ the difference is still more marked, the average for the first 4 intervals being

ANGELL.

t.-i.	1	3	5	7	10	20	30	40	60		
	D	D	D	D	D	D	D	D	D		
$\Delta = \pm 8$	$\left\{ \begin{array}{l} r \\ w \\ 111 \\ ? \end{array} \right.$	51 44 3 1 2 1 2 2 56 48	33 33 2 1 2 1 36 36	29 27 2 1 2 1 32 32	27 22 4 3 1 1 32 24	31 30 3 1 2 5 36 36	30 30 4 2 2 2 36 36	34 33 2 3 2 4 40 40	30 26 3 1 3 3 36 34	26 26 3 1 1 8 6 2 36 36	total= 662
$\Delta = \pm 4$	$\left\{ \begin{array}{l} r \\ w \\ 111 \\ ? \end{array} \right.$	10 17 1 1 4 7 1 1 16 24	25 14 1 1 8 19 2 2 36 36	19 16 3 2 11 15 2 3 36 36	24 25 2 1 14 14 3 3 40 48	22 21 2 3 11 10 1 3 36 35	22 21 2 1 9 9 4 3 35 32	20 17 2 3 8 9 1 4 32 32	16 15 5 7 12 9 3 3 36 34	18 18 6 5 9 8 3 2 35 35	total= 618
$\Delta = 0$	$\left\{ \begin{array}{l} r \\ w \\ ? \end{array} \right.$	14 16 2 2 2 1 18 18	18 14 3 1 I 6 19 17	15 9 1 6 2 3 18 18	15 11 3 6 I 1 18 18	15 11 3 4 I 3 18 18	14 14 4 6 5 2 18 18	7 12 6 4 2 1 18 18	9 5 8 9 I 4 18 18	5 6 12 8 I 3 18 17	total= 160
Total judgments for A. = 1,440											

[illegible]

TABLE II.
Percentage of right judgments in Table I.

LIBBY.

t.-i.	I	3	5	7	10	20	30	40	60
$\Delta = \pm 8$ {	94	93	100	100	100	97	89	92	84
D	100	98	95	100	95	96	93	85	83
$\Delta = \pm 4$ {	88	74	84	74	83	78	75	76	74
D	93	85	82	88	85	82	83	78	87
$\Delta = 0$ {	95	80	70	50	55	30	25	35	10
D	80	90	15	25	10	5	5	0	5

WILSON.

$\Delta = \pm 8$ {	89	90	97	91	95	91	84	80	78
D	79	91	85	89	90	81	77	78	80
$\Delta = \pm 4$ {	70	71	51	82	65	64	76	68	68
D	79	67	68	65	68	73	74	64	60
$\Delta = 0$ {	95	85	100	93	85	55	57	45	18
D	80	70	60	63	45	40	25	55	40

ANGELL.

$\Delta = \pm 8$ {	91	94	94	84	89	86	88	83	79
D	94	93	87	94	90	86	88	82	75
$\Delta = \pm 4$ {	66	72	57	60	60	66	64	49	57
D	71	42	49	60	67	63	59	44	56
$\Delta = 0$ {	83	95	89	83	83	78	72	53	31
D	89	94	58	64	69	53	39	39	42

STEFFENS.

$\Delta = \pm 8$ {	58	60	43	63	57	59	60	50	68
D	66	67	40	73	51	45	61	67	58
$\Delta = \pm 4$ {	50	41	40	53	50	59	56	64	57
D	57	50	43	60	47	66	56	48	71
$\Delta = 0$ {	90	60	35	40	35	5	0	0	5
D	60	28	25	10	18	8	0	3	5

46: for the last 4 it is 59. L. and W. held an intermediate place between S. and A. in this respect. As far as these results go, therefore, no law can be laid down in regard to a decrease in accuracy of the so-called tone-memory for intervals up to 60 seconds: the most that can be said is that there is a small and irregular falling off for some and no falling off for others. In this respect, then, our results are different from Wolfe's.

On the other hand there is a very marked falling off in accuracy of judgment with increase of time interval for $\Delta = 0$: in the case of S. the percentage of right judgments sinks from 90 for 1 second to practically zero for the longer time intervals. With A., however, the corresponding figures are 83 and 31 respectively, indicating, it would seem, less a marked difference in sensitivity than a marked difference in method of judging. Before proceeding to an analysis of results the writers will add Tables III and IV similar to Tables I and II respectively.

These tables are results of experiments carried out the following year with two new reagents, Mrs. Mary George and Mr. Bullock—as a test of the results in Tables I and II. And here it may be said that both series of experiments were conducted under very favorable circumstances; no other experiments were allowed to go on in the laboratory at the same time; the laboratory building itself was situated in a field with but one occupied building in its vicinity. Finally, the reagents themselves were all earnest and strenuous. The conditions of the

TABLE III.

Second group of Reagents. Symbols as in Table I.

GEORGE.

t.-i	1	3	5	7	10	20	30	40	60		
	D	D	D	D	D	D	D	D	D		
$\Delta=\pm 8$	$\begin{Bmatrix} r \\ w \\ lll \\ ? \end{Bmatrix}$	$\begin{Bmatrix} 20 & 20 \\ 2 & 4 \end{Bmatrix}$	$\begin{Bmatrix} 18 & 21 \\ 3 & 2 \end{Bmatrix}$	$\begin{Bmatrix} 20 & 22 \\ 1 & 1 \end{Bmatrix}$	$\begin{Bmatrix} 21 & 19 \\ 2 & 3 \end{Bmatrix}$	$\begin{Bmatrix} 36 & 35 \\ 3 & 4 \end{Bmatrix}$	$\begin{Bmatrix} 52 & 48 \\ 2 & 8 \end{Bmatrix}$	$\begin{Bmatrix} 43 & 53 \\ 4 & 3 \end{Bmatrix}$	$\begin{Bmatrix} 39 & 31 \\ 6 & 10 \end{Bmatrix}$	$\begin{Bmatrix} 38 & 37 \\ 6 & 8 \end{Bmatrix}$	
	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	
		$\begin{Bmatrix} 23 & 24 \\ 22 & 24 \end{Bmatrix}$	$\begin{Bmatrix} 24 & 24 \\ 24 & 24 \end{Bmatrix}$	$\begin{Bmatrix} 24 & 24 \\ 24 & 24 \end{Bmatrix}$	$\begin{Bmatrix} 40 & 40 \\ 40 & 40 \end{Bmatrix}$	$\begin{Bmatrix} 56 & 58 \\ 56 & 58 \end{Bmatrix}$	$\begin{Bmatrix} 56 & 56 \\ 48 & 48 \end{Bmatrix}$	$\begin{Bmatrix} 48 & 48 \\ 48 & 48 \end{Bmatrix}$	$\begin{Bmatrix} 48 & 48 \\ 48 & 48 \end{Bmatrix}$	$\begin{Bmatrix} 48 & 48 \\ 48 & 48 \end{Bmatrix}$	total= 687
$\Delta=\pm 4$	$\begin{Bmatrix} r \\ w \\ lll \\ ? \end{Bmatrix}$	$\begin{Bmatrix} 13 & 14 \\ 6 & 8 \end{Bmatrix}$	$\begin{Bmatrix} 19 & 16 \\ 3 & 6 \end{Bmatrix}$	$\begin{Bmatrix} 18 & 16 \\ 4 & 5 \end{Bmatrix}$	$\begin{Bmatrix} 15 & 16 \\ 5 & 5 \end{Bmatrix}$	$\begin{Bmatrix} 42 & 39 \\ 4 & 15 \end{Bmatrix}$	$\begin{Bmatrix} 55 & 54 \\ 15 & 15 \end{Bmatrix}$	$\begin{Bmatrix} 58 & 44 \\ 21 & 26 \end{Bmatrix}$	$\begin{Bmatrix} 45 & 45 \\ 18 & 16 \end{Bmatrix}$	$\begin{Bmatrix} 47 & 52 \\ 22 & 13 \end{Bmatrix}$	
	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	
		$\begin{Bmatrix} 22 & 22 \\ 22 & 22 \end{Bmatrix}$	$\begin{Bmatrix} 22 & 22 \\ 24 & 24 \end{Bmatrix}$	$\begin{Bmatrix} 24 & 24 \\ 24 & 24 \end{Bmatrix}$	$\begin{Bmatrix} 24 & 24 \\ 72 & 74 \end{Bmatrix}$	$\begin{Bmatrix} 78 & 87 \\ 87 & 86 \end{Bmatrix}$	$\begin{Bmatrix} 86 & 90 \\ 90 & 88 \end{Bmatrix}$	$\begin{Bmatrix} 88 & 80 \\ 80 & 80 \end{Bmatrix}$	$\begin{Bmatrix} 80 & 80 \\ 79 & 80 \end{Bmatrix}$	$\begin{Bmatrix} 79 & 80 \\ 79 & 80 \end{Bmatrix}$	total=1,000
$\Delta=0$	$\begin{Bmatrix} r \\ w \\ ? \end{Bmatrix}$	$\begin{Bmatrix} 9 & 6 \\ 3 & 6 \end{Bmatrix}$	$\begin{Bmatrix} 10 & 6 \\ 2 & 6 \end{Bmatrix}$	$\begin{Bmatrix} 7 & 5 \\ 5 & 7 \end{Bmatrix}$	$\begin{Bmatrix} 6 & 3 \\ 6 & 9 \end{Bmatrix}$	$\begin{Bmatrix} 15 & 12 \\ 13 & 16 \end{Bmatrix}$	$\begin{Bmatrix} 11 & 10 \\ 25 & 26 \end{Bmatrix}$	$\begin{Bmatrix} 14 & 9 \\ 22 & 27 \end{Bmatrix}$	$\begin{Bmatrix} 15 & 12 \\ 17 & 20 \end{Bmatrix}$	$\begin{Bmatrix} 10 & 12 \\ 22 & 20 \end{Bmatrix}$	
	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	$\begin{Bmatrix} I \\ ? \end{Bmatrix}$	total= 424
Total judgments for G.=1,211											

BULLOCK.

t.-i.	I	3	5	7	10	20	30	40	60									
	D	D	D	D	D	D	D	D	D									
$\Delta = \pm 8$	$\left\{ \begin{array}{l} r \\ w \\ 111 \\ ? \end{array} \right.$	17 3 I I	17 2 I 2	16 I 2 I	21 20 I 3	19 21 I 3	34 27 I 6	42 45 I 5	50 39 4 2	40 37 3 5	36 35 II 9							
	20	20	24	20	24	24	24	40	40	56	56	56	50	48	48	48	49	total= 67r
$\Delta = \pm 4$	$\left\{ \begin{array}{l} r \\ w \\ 111 \\ ? \end{array} \right.$	17 4 I I	17 3 I 2	18 I I 5	17 I 4 6	16 I 3 2	16 19 3 5	33 31 II II	43 48 I 8	59 41 8 19	54 40 I 8	46 37 I 14	3 12 3 12	63 64	63 64	63 64	total= 85r	
$\Delta = 0$	$\left\{ \begin{array}{l} r \\ w \\ ? \end{array} \right.$	12 10 2	12 9 I	8 7 4	7 8 5	8 6 4	20 15 9	16 14 16	17 17 13	17 17 13	13 10 4	13 14 16	14 II I	28 28	28 28	28 28	3	total= 38r
	12	12	12	12	12	12	24	24	32	30	32	31	28	28	28	28	3	Total judgments for B.= 1,903

TABLE IV.

Percentage of right judgments in Table III; about three times as many judgments for intervals from 10 seconds to 60 seconds as for intervals 1 second to 7 seconds.

GEORGE.

t.-i.	1	3	5	7	10	20	30	40	60
$\Delta = \pm 8$ {	88	84	85	87	90	93	93	81	79
D {	83	87	91	79	87	86	77	65	78
$\Delta = \pm 4$ {	59	86	79	64	58	63	64	56	60
D {	64	73	66	69	53	63	50	56	65
$\Delta = 0$ {	75	83	58	50	54	30	66	47	31
D {	50	50	42	25	43	28	25	37	37

BULLOCK.

t.-i.	1	3	5	7	10	20	30	40	60
$\Delta = \pm 8$ {	85	92	87	79	85	75	89	83	75
D {	88	83	83	87	68	81	78	78	75
$\Delta = \pm 4$ {	77	77	71	67	59	62	82	73	74
D {	77	82	71	79	56	67	52	65	59
$\Delta = 0$ {	100	100	67	67	83	50	43	75	48
D {	83	79	58	50	62	47	55	39	47

experimentation were as in the first group—the reagents being kept in complete ignorance of its course. The chief difference lay in the methods of distraction and in increasing the relative number of judgments for the longer intervals—from two to three times as many judgments being given on the intervals from 10 seconds to 60 seconds as on those from 1 second to 7 seconds.

The results of these experiments corroborate those of the preceding group: as before, in agreement with Wolfe, there is a marked falling off in right judgments with lengthening time for $\Delta = 0$:—on the other hand there is no marked and regular falling off with the time for $\Delta = \pm 8$ or $\Delta = \pm 4$. Comparing the longest with the shortest intervals one gets:—

		Average of four intervals 1 sec. to 7 secs.	Average of four intervals 20 secs. to 60 secs.
George	$\Delta = \pm 8$	84	84.5
	$\Delta = \pm 4$	72	60.7
Bullock	$\Delta = \pm 8$	85.7	80.5
	$\Delta = \pm 4$	73	72.7

If G. shows a falling off for the longer intervals with $\Delta = \pm 4$, she shows none for $\Delta = \pm 8$. B. on the other hand shows a falling for the greater difference, but practically is as accurate on the longer interval as on the shorter for the smaller differ-

ence. So far as these results go, there can be no general law of sensory memory.

Even for $\Delta = 0$ the individual variations are far too great to admit of other than the very broad statement that the number of correct judgments decreases with the time interval.

The writers are not able to explain satisfactorily the discrepancy between Wolfe's results and their own. The main difference is perhaps that in Wolfe's work the reagents knew what the value of Δ was which they were judging:—whether it was a difference of 4, 8 or 12 valuations—while in the writers' work none of reagents knew anything in regard to the value of Δ . This difference in the mental attitude of the reagents is reflected in the results, as Wolfe's reagents did not respond to variations in the value of Δ as closely as one would have expected. Wolfe himself is of the opinion that with the greater differences the attention was less strained—whether during the action of the stimuli or during the time interval he does not specify.

Acting at once as reagent and experimenter, Wolfe contributed to his data far more judgments than any other reagent, but we do not find that his general results differ so much from those of the other reagents as to warrant the inference that his knowledge of the course of the experimentation affected the work very differently from the knowledge of the other reagents.

A further difference between Wolfe's method and our own lies in the fact that in our work the number of judgments for $\Delta = 0$, was about $\frac{1}{3}$ of those for $\Delta = \pm 4$, or for $\Delta = \pm 8$, while in the earlier work the number of judgments for $\Delta = 0$ was greater than for the other differences. When one considers the diversity of results produced by different mental attitudes, together with the great difficulty of reproducing accurately all the conditions under which a given set of psychological experiments is made, one is almost tempted to say that it is likeness of result, not unlikeness, which calls for explanation in work of this kind.

As far as the writers' results go, however, there is no question of a loss of sensory memory: the individual variations are so great in both groups of experiments as to indicate that we have to do with certain specific ways of forming judgments rather than with a general way of depending on the presence of a more or less fleeting 'memory image.'

The discussion of the 'memory image' theory in the light of the distraction experiments, together with a consideration of specific ways of forming judgments of like or unlike, will occupy the second part of this paper.

(Part II to follow.)